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ABSTRACT

A study was designed to determine the effects of various ball sizes on children s catching ability and to examine the results as a between- and within-group factor. It was believed that the use of the two-test design would help to establish the validity of past and future tests of this nature. The between-subjects design group consisted of 48 first grade children who were required to make a series of catches using one ball size (6 inch, 8.5 inch, or 10 inch diameter). Each of the children on the within-subjects group received a total of 12 trials, catching all three ball sizes in random order. Since the initial analysis showed a significant trials effect as the subjects adapted to the task, data were modified to reduce this effect. Subsequent analyses showed that the only significant interactions in the between-subject design situation was between the size of the ball and the gender of the subject. For the within-subjects design group, only the main effect of the ball size was significant. The 10 inch diameter ball resulted in more successful catching than the 6 inch ball. The two design types appeared to be interchangeable in the paradigm. (FG)

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Effects of Object Size and Experimental Design On Object Reception by Children in the First Grade

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Abstract - Subjects (24 boys and 24 girls) from the first grade (between-subjects design group) were required to make a series of 12 catches using only one ball size (6-, 8.5-, or 10-in. diameter). Another group comprised of 8 boys and 8 girls was administered 36 trials which consisted of all 3 ball sizes presented in random order (within-subjects design group). Each catch was evaluated using a five-point scale. Following an analysis of the between-subjects group data it was determined that a significant ball size by sex interaction existed. Following a similar analysis of the within-subjects group data it was determined that the factor of ball size for these subjects was significant. The 10" diameter ball resulted in significantly more successful catching than the 6 " ball size. No differences were noted between the 10" and the 8.5" ball diameter nor between the 8.5" and the 6" ball diameter. In the establishment of teaching progressions for catching relative to ball size the large ball size appears to be a logical starting point.

When contrasting the two design types an analysis of variance was employed followed by a Satterthwaite approximation. It was determined that no significant difference existed between these design types. They do, therefore, appear to be interchangeable for this particular paradigm.

Task analyses or skill sequences exist to aid teachers in the establishment of proper teaching progressions for various movement skills. Unfortunately, the existing information is, in most cases, the result of empirical, not scientific evidence. Object reception, or simply catching, is a basic movement pattern that has been sequenced but insufficiently researched. Many variables affect the success of a child's catching attempt and, therefore, should be considered in the development of a scientifically based teaching progression. For example, is a large, medium or small ball most conducive to successful catching performance? That ball size yielding the most successful catches would appear to be the simplest task for the recipient. Thereby, a simple to complex sequence for ball size could be established for catching. The effects of ball size on catching performance has been examined previously. Discrepancies exist, however, in the results of those investigations.

Payne and Koslow (1981) for example, in an examination of children in Kindergarten, first, and second grades, found that the large ball size (13-in. diameter) resulted in superior catching performances than 3 smaller sized balls when projected to the subject across a horizontal distance of 4-ft. In a similar study, Meyer (1956), using balls of 17-in., 8-in., 5-in., and 3.5 in. diameters, found that kindergarten children successfully caught a greater percentage of the larger balls. As ball size increased, performance improved on the catching task involved in the study. McKaskill and Wellman (1938) also examined catching skills. Using preschool children balls of 16.25-, and 9.5-in. circumferences and a simple success/failure criterion, these researchers concluded that success occurred at an earlier

age when a larger ball size was employed. The research of Meadley (1941) led to similar conclusions. In this investigation children at the elementary school level were examined. Meadley determined that "medium" to "large" sized balls resulted in the most positive catching performances for girls in grades 1 and 2 and boys in grades 1-4. She concluded that, for teaching catching skills to children at the First Grade level, soccer and volleyball sized balls should be employed.

Despite the concurrence of the above studies in recommending larger ball sizes for improving catching success of young children, a plethora of research has yielded contrasting recommendations. Isaacs (1980) investigated this area using 7 and 8-yr.-old children and ball sizes of 6-, 8.5-, and 10-in. diameters. Using a 6-pt. scale for evaluating the catches, Isaacs concluded that the catches made with the 6-in. diameter ball were of a significantly higher quality than when the larger sized balls were used. Isaacs stated that as the ball size increased in size the catching technique retrogressed to a more immature state. Seils (1951) administered 10 catches per ball size to the primary grade children involved in yet another investigation of catching performance. Catches attempted with tennis balls were more successful than catches with a softball or a squash ball. Gutteridge (1939) also concluded that ball size has a definite effect on a child's ability to catch. Using balls of 12-, 8-, 6-, and 5-in. diameters Gutteridge determined that the greatest percentage of children 5-yrs. of age were successful when the 5-in. ball was employed.

Ridenour (1974) examined children's reaction time to various sized

spheres. Using 6- and 7-yr.-old children Ridenour determined that a child's ability to predict directionality is not a function of the object's size. Therefore, she concluded, large balls are not necessarily more appropriate than small balls for use with young children.

From this review it appears apparent that vast differences have resulted in the conclusions of the researchers cited. Although Payne and Koslow (1981), Meyer (1956) and McKaskill and Wellman (1938) and Meadley (1941) found the larger ball sizes to be more conducive to successful catching performance, Isaacs (1980), Seils (1951), Gutteridge (1939), and Ridenour produced evidence to the contrary. Such differences may have occurred as a result of the style of projection employed in the study, the distances across which the balls were projected, the criterion (rating scale) for evaluation, the ball type, or the experimental design.

According to Grice (1966), researchers frequently select an experimental design based on administrative expediency. Unfortunately, the design which is most efficient may produce invalid results if the potential significance of a design effect is not recognized. Grice, therefore, recommended that direct comparisons of within- and between-subject design types be made. This is a requirement, he stated, of all behavioral research. If a design effect were determined, a resulting difference in treatments could be attributed to the design. It is apparent that without recognition of this fact the difference between treatment means would otherwise be attributed to the treatment effect. In fact, no significant differences may have resulted as a function of that treatment had it not been for the design type. One purpose of this investigation was to examine

the effects of various ball diameters on the object reception of young children. A second purpose, however, was to examine this question as a between- and a within-subjects factor. Using both design types would determine if they are interchangeable designs or if a design effect has, in fact, resulted. Such information would be valuable in the analysis of past literature and beneficial in the design of future investigations.

Method

Subjects

Subjects from the First Grade (48) were randomly assigned to a ball size group (6-, 8.5-, 10-in. diameter). These subjects (24 girls and boys) were asked to attempt 12 catches using only the ball assigned to their group (between-subjects design group). Subjects (16) from an independent sample were randomly assigned to a group which was administered 36 trials using a random presentation of all three ball sizes. Each ball was, therefore, received 12 times by these 8 boys and 8 girls (within-subjects design group). This design was employed as suggested by Erlebacher (1977).

Procedure

A special device was designed to accurately project the balls with a consistent speed and trajectory. The subject stood 6 horizontal ft. from the device. Following a "ready" signal the ball was projected to the sub-

Insert Figure 1
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ject and the subsequent catch, or attempted catch, was evaluated using a 5-pt. rating scale: 1, failure to react; 2, one hand contact, ball dropped;

3, two hands contact, ball dropped; 4, uncontrolled catch (ball is bobbled); 5, controlled catch. This scale had been used previously in studies involving the catching performance of children (Victors, 1961; Bruce, 1966; Pederson, 1973). Such a tool was selected for use in this investigation to quantify the success of the catching attempt. This scale was determined to be reliable (r = .96) in a pilot investigation (Payne and Koslow, 1981). In that pilot study 18 children were evaluated in their performance on 28 catches. Each trial was videotaped for re-evaluation by a second judge. A Kendall Coefficient of Concordance was used to compute the reliability.

The results were analyzed using an analysis of variance as recommended by Keppel (1973), with the .05 level of significance being applied on all tests of significance. For analysis of the design effect, data from both design type groups were pooled and similarly analyzed. In this case, however, a Satterthwaite (1946) approximation was also applied since a comparison of correlated with uncorrelated data was being made. A negatively biased F ratio would otherwise be expected to result. A Scheffé *post hoc* analysis was applied where significant main effects resulted.

Results

Upon the initial analysis of both the within-subjects and the between-subjects group data, it was determined that a significatn trials effect existed. By examining the plotted data, it appeared obvious that the trials effect was a result of the subjects' adaptation to the task. The initial trials indicated noticeably less success than the latter trials. In fact, except for the initial adaptation period, trials plateaued indi-

cating a consistent performance level. Since, success in catching was being examined in this study, not adaptation, it was deemed necessary to remove initial trials from the analysis until the significance of the trials factor was removed. The first trial from the data of each subject in the within-subjects design group and the first 3 trials from the data of each subject in the between-subjects design group were removed. The analysis of variance performed on this modified data revealed that the between-subjects design situation yielded a significant ball size by sex interaction. (See Table 1). No other interactions or main effects were found to be significant. For the within-subjects design situation only the main effect of

Insert Table 1
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ball size was significant. (See Table 2). Upon the completion of a Scheffé post hoc analysis, it was determined that the 10 in. diameter ball resulted in

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significantly superior catching performances than the ball with a 6 in. diameter. No significant difference was noted between the 10 in. ball and the 8.5 in. ball nor between the 8.5 in. ball and the 6 in. ball size for this design situation. The main effect of design was not found to be a significant factor.

Discussion

Gender, in this study, was not found to be a significant main effect for catching performance for first grade children. This finding is supported by the research of Payne and Koslow (1981). In that study it was found

that, although the main effect of sex was significant for children from kindergarten through second grade, the mean scores for boys and girls at the first grade level were identical.

From a general examination of the results of this investigation it appears that larger balls result in more successful catching performance than the smaller balls. However, upon closer examination, it becomes apparent that the performance of the female subjects (between-subjects group) actually regressed with the 10 in. diameter ball to a point only slightly superior to the performances when receiving the 6 in. diameter ball (see figure 2). It must be concluded, therefore, that larger balls appear to produce superior catching success by boys in the first grade. However, the most success by the female subjects appears to occur when using either a middle (8.5-in.) or larger (10-in.) sized ball depending on the catching situation. Therefore, a logical starting point in a teaching progression for catching relative to ball size would be the larger sized ball (10-in.) for the males and the medium (8.5-in.) or large sized balls for the females.

Insert Figure 2
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The two designs compared here, the between-subjects and the within-subjects, were not found to differ significantly (See Table 3). For this

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paradigm, therefore, these design types appear to work interchangeably. This is a conclusion that contrasts with the majority of past experimentation in this area. Lueft (1968), for example, in examining response

speed as a function of design type concluded that the within-subjects treatments inhibited responses relative to the between-subjects treatment. Similarly, Kimble, Leonard, and Perlmuter (1968) concluded that interstimulus interval function differs significantly depending on the design type. Again, according to these researchers, responses were inhibited during within-subjects treatments. Cermak (1967) examined galvanic skin response conditioning using two design types. The within-subjects design resulted with a significantly smaller error term than between-subjects design in this study. The conclusion was again made that the within-subject design can result in differential behavior effects. Unlike the results of this study, the majority of investigation comparing design types has led to the conclusion that the between- and the within-subjects designs are not interchangeable. The interchangeability of these designs is a function, however, of the factors under examination. Based on the results of this study these designs do appear to be interchangeable for examinations of ball size and their relationship to catching success in children. Discrepancies in past literature are not likely, therefore, to be a result of the design type employed. Those differences could be attributable to the ball type employed, the distance the ball was projected, or the type of system used to evaluate the catch. Further research is needed to make that determination.

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TABLE 1. ANALYSIS OF VARIANCE OF THE EXAMINATION OF THE EFFECTS OF BALL DIAMETER ON OBJECT RECEPTION BY CHILDREN IN THE FIRST GRADE (BETWEEN-SUBJECTS)

Sources of Variation	Sums of Squares	df	Mean Squares	F
Between-Subjects				
Ball Size	3.43	2	1.715	2.52
Sex	1.69	1	1.688	2.48
Ball Size x Sex	6.01	2	3.007	4.42*
Subjects Within Grade and Sex	28.57	42	.680	
Within-Subjects				
Trial	2.71	8	.339	1.24
Sex x Trial	2.04	8	.255	.93
Ball Size x Trial	2.40	16	.150	.55
Ball Size x Sex xTrial	2.82	16	.176	.64
Residual	91.81	336	.273	

*Significant at the .05 level.

TABLE 2. ANALYSIS OF VARIANCE OF THE EXAMINATION OF THE EFFECTS OF BALL DIAMETER ON OBJECT RECEPTION BY CHILDREN IN THE FIRST GRADE (WITHIN-SUBJECTS)

Sources of Variation	Sums of Squares	df	Mean Squares	F
Between-Subjects				
Sex	.05	1	.047	.02
Subjects Within Sex	28.24	14	2.017	
Within-Subjects				
Ball Size	5.53	2	2.767	7.80*
Sex x Ball Size	.05	2	.025	.07
Ball Size x Subjects Within Sex	9.93	28	.355	
Trial	4.18	10	.418	1.76
Sex x Trial	4.06	10	.406	1.71
Trial x Subjects Within Sex	33.22	140	.237	
Ball Size x Trial	4.42	20	.221	1.08
Sex x Trial x Ball Size	1.91	20	.095	.47
Residual	57.48	280	.205	

*Significant at the .05 level.

TABLE 3. MEANS AND STANDARD DEVIATIONS BY BALL SIZE AND EXPERIMENTAL DESIGN

	BETWEEN-SUBJECTS DESIGN	WITHIN-SUBJECTS DESIGN
6" DIAM.	4.234 .616	4.260 .556
8.5" DIAM.	4.391 .568	4.385 .499
10" DIAM.	4.453 .568	4.505 .512
TOTAL	4.359 .591	4.384 .531